CHAPTER 16. ENVIRONMENTAL ASSESSMENT

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CHAPTER 16. ENVIRONMENTAL ASSESSMENT

16.1 INTRODUCTION

This chapter describes potential environmental effects that may result from amended energy conservation standards for residential cooking products. The U.S. Department of Energy (DOE)'s proposed energy conservation standards are not site-specific, and would apply to all 50 States and U.S. territories. Therefore, none of the proposed standards would impact land uses, cause any direct disturbance to the land, or directly affect biological resources in any one area.

All of the potential trial standard levels (TSLs) are expected to reduce energy consumption in comparison to a baseline efficiency level. These changes in the demand for electricity and the costs of achieving these savings are the primary drivers in analyzing environmental effects. Estimates of source energy savings can be found in the national impact analysis in Chapter 11 of this technical support document (TSD). Detailed discussion on TSLs can be found in Chapter 9 of this TSD.

The primary impact of the TSLs is in air quality resulting from changes in power plant operations and capacity additions. Therefore, much of this chapter describes the air quality analysis. The latter part of the chapter describes potential impacts to other environmental resources.

The TSD for DOE's notice of proposed rulemaking (NOPR) covered conventional cooking products (i.e., cooktops and ovens), microwave oven energy factor (EF), microwave oven standby power consumption, and commercial clothes washers (CCW).[1] This chapter presents information and results pertaining solely to conventional cooking products and microwave oven EF. The impact of more-efficient equipment on microwave oven standby power and CCWs will be addressed in subsequent TSDs.

16.2 AIR EMISSIONS ANALYSIS

The primary focus of the environmental analysis is the impact on air quality of amended energy conservation standards for residential cooking products. The outcomes of the environmental analysis are driven by changes in power plant types and quantities of electricity generated under each of the alternatives. Changes in generation are described in the utility impact analysis in Chapter 14.

16.2.1 Air Emissions Descriptions

For each of the TSLs, DOE calculated total power-sector emissions based on output from NEMS-BT model (see Chapter 14). This analysis considers three pollutants: nitrogen oxides (NO_x), mercury (Hg), and sulfur dioxide (SO_2). An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may be natural or man-made (i.e., anthropogenic) and may take the form of solid particles (i.e., particulates or particulate matter), liquid droplets, or gases[a]. This analysis also considers carbon dioxide (CO_2).

Sulfur Dioxide (SO_2)

In addressing SO_2 emissions, the Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. This SO_2 trading process (sometimes called "cap and trade") implies that the standard will have no affect on total physical emissions because emissions will always be at, or near, the allowed emissions ceiling. Consequently, there is no direct SO_2 environmental benefit from a reduction in electricity use due to the proposed energy conservation standards, as long as there is enforcement of the emissions ceiling. But to the extent reduced power generation demand decreases the demand for and price of emissions allowance permits, there is an environmentally related economic benefit from the proposed energy conservation standards reducing SO_2 emissions allowance demand. Furthermore, over time, if emissions decline, there is greater flexibility in reducing the ceiling amount. However, since DOE does not anticipate a change in SO_2 emissions, SO_2 emission results are not reported in this Chapter.

Nitrogen Oxides (NO_x)

Nitrogen oxides**,** or NO_x, are the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2), along with particles in the air can often be seen as a reddish-brown layer over many urban areas. NO_2 is the specific form of NOx reported in this document. NO_x is one of the main ingredients involved in the formation of ground-level ozone, which can trigger serious respiratory problems. It can contribute to the formation of acid rain, and can impair visibility in areas such as national parks. NO_x also contributes to the formation of fine particles that can impair human health.

Nitrogen oxides form when fossil fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NO_x are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fossil fuels. NO_x can also be formed naturally. Electric utilities account for about 22 percent of NO_x emissions in the United States.

Mercury

Coal-fired power plants emit Hg found in coal during the burning process. While coal-fired power plants are the largest remaining source of human-generated Hg emissions in the United States, they contribute very little to the global Hg pool or to contamination of U.S.

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[a] More information on air pollution characteristics and regulations is available on the U.S. Environment Protection Agent (EPA)'s website at www.epa.gov.

waters. U.S. coal-fired power plants emit Hg in three different forms: oxidized Hg (likely to deposit within the United States); elemental Hg, which can travel thousands of miles before depositing to land and water; and Hg that is in particulate form. Atmospheric Hg is then deposited on land, lakes, rivers, and estuaries through rain, snow, and dry deposition. Once there, it can transform into methylmercury and accumulate in fish tissue through bioaccumulation.

Americans are exposed to methylmercury primarily by eating contaminated fish. Because the developing fetus is the most sensitive to the toxic effects of methylmercury, women of childbearing age are regarded as the population of greatest concern. Children exposed to methylmercury before birth may be at increased risk of poor performance on neurobehavioral tasks, such as those measuring attention, fine motor function, language skills, visual-spatial abilities, and verbal memory.

Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is not a regulated or criteria pollutant (see below), but it is of interest because of its classification as a greenhouse gas (GHG). GHGs trap the sun's radiation inside the Earth's atmosphere and either occur naturally in the atmosphere or result from human activities. Naturally occurring GHGs include water vapor, CO_2, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Human activities, however, add to the levels of most of these naturally occurring gases. For example, CO_2 is emitted to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood, and wood products are burned. During the past 20 years, about three-quarters of anthropogenic (i.e., human-made) CO_2 emissions resulted from burning fossil fuels.

Concentrations of CO_2 in the atmosphere are naturally regulated by numerous processes, collectively known as the "carbon cycle." The movement of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. While these natural processes can absorb some of the anthropogenic CO_2 emissions produced each year, billions of metric tons are added to the atmosphere annually. In the U. S., CO_2 emissions from both energy generation and industrial processes account for 84.6 percent of total U.S. GHG emissions.

16.2.2 Air Quality Regulation

The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that EPA is required to control. EPA has set national air quality standards for six common pollutants (also referred to as "criteria" pollutants), two of which are SO_2 and NO_x. Also, the Clean Air Act Amendments of 1990 gave EPA the authority to control acidification and to require operators of electric power plants to reduce emissions of SO_2 and NO_x. Title IV of the 1990 amendments established a cap-and-trade program for SO_2 intended to help control acid rain. This cap-and-trade program serves as a model for more recent programs with similar features.

In 2005, EPA issued the Clean Air Interstate Rule (CAIR) under sections 110 and 111 of the Clean Air Act (40 CFR Parts 51, 96, and 97).[b] CAIR will permanently cap emissions of SO_2 and NOx in eastern States of the United States. CAIR achieves large reductions of SO_2 and/or NOx emissions across 28 eastern states and the District of Columbia. States must achieve the required emission reductions using one of two compliance options: 1) meet an emission budget for each regulated state by requiring power plants to participate in an EPA-administered interstate cap-and-trade system that caps emissions in two stages, or 2) meet an individual state emissions budget through measures of the state's choosing. Phase 1 caps for NO_x are to be in place in 2009. Phase 1 caps for SO_2 are to be in place in 2010. The Phase 2 caps for both pollutants are due in 2015.

Also in 2005, EPA issued the final rule entitled "Standards of Performance for New and Existing Stationary Sources: Electric Steam Generating Units," under sections 110 and 111 of the Clean Air Act (40 CFR Parts 60, 63, 72, and 75). This rule, also called the Clean Air Mercury Rule (CAMR), was closely related to the CAIR and established standards of performance for Hg emissions from new and existing coal-fired electric utility steam generating units. The CAMR regulated Hg emissions from coal-fired power plants.

On February 8, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in State of New Jersey, *et al.* v. Environmental Protection Agency,[c] in which the Court, among other actions, vacated the CAMR referenced above.

On July 11, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in North Carolina v. Environmental Protection Agency, which vacated the CAIR issued by the U.S. Environmental Protection Agency on March 10, 2005.[d] But on December 23, 2008, the D.C. Circuit decided to allow CAIR to remain in effect until it is replaced by a rule consistent with the court's earlier opinion. North Carolina v. Environmental Protection Agency, 550 F.3d 1176 (D.C. Cir. 2008) (remand of vacatur).

16.2.3 Global Climate Change

Climate change has evolved into a matter of global concern because it is expected to have widespread, adverse effects on natural resources and systems. A growing body of evidence points to anthropogenic sources of greenhouse gases, such as carbon dioxide (CO_2), as major contributors to climate change. Because this Rule, if finalized, will likely decrease CO_2 emission rates from the fossil fuel sector in the United States, the Department here examines the impacts and causes of climate change and then the potential impact of the Rule on CO_2 emissions and global warming.

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[b] See http://www.epa.gov/cleanairinterstaterule/.

[c] No. 05-1097, 2008 WL 341338, at *1 (D.C. Cir. Feb. 8, 2008).

[d] See http://www.epa.gov/cleanairinterstaterule/.

Impacts of Climate Change on the Environment

Climate is usually defined as the average weather, over a period ranging from months to many years. Climate change refers to a change in the state of the climate, which is identifiable through changes in the mean and/or the variability of its properties (e.g., temperature or precipitation) over an extended period, typically decades or longer.

The World Meteorological Organization and United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) to provide an objective source of information about climate change. According to the IPCC Fourth Assessment Report (IPCC Report), published in 2007, climate change is consistent with observed changes to the world's natural systems; the IPCC expects these changes to continue.

Changes that are consistent with warming include warming of the world's oceans to a depth of 3000 meters; global average sea level rise at an average rate of 1.8 mm per year from 1961 to 2003; loss of annual average Arctic sea ice at a rate of 2.7 % per decade, changes in wind patterns that affect extra-tropical storm tracks and temperature patterns, increases in intense precipitation in some parts of the world, as well as increased drought and more frequent heat waves in many locations worldwide, and numerous ecological changes.

Looking forward, the IPCC describes continued global warming of about 0.2°C per decade for the next two decades under a wide range of emission scenarios for carbon dioxide (CO_2), other greenhouse gases (GHG)s, and aerosols. After that period, the rate of increase is less certain. The IPCC Report describes increases in average global temperatures of about 1.1°C to 6.4°C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios.

The IPCC Report describes incremental impacts associated with the rise in temperature. At ranges of incremental increases to the global average temperature, IPCC reports, with either high or very high confidence, that there is likely to be an increasing degree of impacts such as coral reef bleaching, loss of wildlife habitat, loss to specific ecosystems, and negative yield impacts for major cereal crops in the tropics, but also projects that there likely will be some beneficial impacts on crop yields in temperate regions.

Causes of Climate Change

The IPCC Report states that the world has warmed by about 0.74°C in the last 100 years. The IPCC Report finds that most of the temperature increase since the mid-20th century is very likely due to the increase in anthropogenic concentrations of CO_2 and other long-lived greenhouse gases (GHGs) such as methane and nitrous oxide in the atmosphere, rather than from natural causes.

Increasing the CO_2 concentration partially blocks the earth's re-radiation of captured solar energy in the infrared band, inhibits the radiant cooling of the earth, and thereby alters the energy balance of the planet, which gradually increases its average temperature. The IPCC

Report estimates that currently, CO_2 makes up about 77% of the total CO_2-equivalent[e] global warming potential in GHGs emitted from human activities, with the vast majority (74%) of the CO_2 attributable to fossil fuel use. For the future, the IPCC Report describes a wide range of GHG emissions scenarios, but under each scenario CO_2 would continue to comprise above 70% of the total global warming potential.

Stabilization of CO_2 Concentrations

Unlike many traditional air pollutants, CO_2 mixes thoroughly in the entire atmosphere and is long-lived. The residence time of CO_2 in the atmosphere is long compared to the emission processes. Therefore, the global cumulative emissions of CO_2 over long periods determine CO_2 concentrations because it takes hundreds of years for natural processes to remove the CO_2. Globally, 49 billion metric tons of CO_2 –equivalent of anthropogenic (man-made) greenhouse gases are emitted every year. Of this annual total, fossil fuels contribute about 29 billion metric tons of CO_2.[f]

Researchers have focused on considering atmospheric CO_2 concentrations that likely will result in some level of global climate stabilization, and the emission rates associated with achieving the "stabilizing" concentrations by particular dates. They associate these stabilized CO_2 concentrations with temperature increases that plateau in a defined range. For example, at the low end, the IPCC Report scenarios target CO_2 stabilized concentrations range between 350 ppm and 400 ppm (essentially today's value)—because of climate inertia, concentrations in this low end range would still result in temperatures projected to increase 2.0°C to 2.4°C above pre-industrial levels[g] (about 1.3°C to 1.7°C above today's levels). To achieve concentrations between 350 ppm to 400 ppm, the IPCC scenarios present that there would have to be a rapid downward trend in total annual global emissions of greenhouse gases to levels that are 50% to 85% below today's annual emission rates by no later than 2050. Since it is assumed that there would continue to be growth in global populations and substantial increases in economic production, the scenarios identify required reductions in greenhouse gas emissions intensity (emissions per unit of output) of more than 90%. However, even at these rates, the scenarios describe some warming and some climate change is projected due to already accumulated CO_2 and GHGs in the atmosphere.

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[e] GHGs differ in their warming influence (radiative forcing) on a global climate system due to their different radiative properties and lifetimes in the atmosphere. These warming influences may be expressed through a common metric based on the radiative forcing of CO_2, i.e., CO_2-equivalent. CO_2 equivalent emission is the amount of CO_2 emission that would cause the same- time integrated radiative forcing, over a given time horizon, as an emitted amount of other long- lived GHG or mixture of GHGs.

[f] Other non-fossil fuel contributors include CO_2 emissions from deforestation and decay from agriculture biomass; agricultural and industrial emissions of methane; and emissions of nitrous oxide and fluorocarbons.

[g] IPCC Working Group 3 Table TS 2

The Beneficial Impact of the Rule on CO_2 Emissions

If finalized, it is anticipated that the Rule will reduce energy-related CO_2 emissions, particularly those associated with energy consumption in buildings. In the United States, the U.S. Energy Information Administration (EIA) reports in its 2008 Annual Energy Outlook (*AEO2008*)[2] that U.S. annual energy-related emissions of CO_2 in 2005 were about 6.0 billion metric tons (about 20 percent of the world energy-related CO_2 emissions and about 12 percent of total global greenhouse gas emissions), of which 2.3 billion tons were attributed to residential and commercial buildings sector (including related energy–using equipment such as residential cooking products). Most of the greenhouse gas emissions attributed to residential and commercial buildings are emitted from fossil fuel-fired power plants that generate electricity used in this sector. In the *AEO2008* Reference Case, EIA projected that annual energy-related CO_2 emissions would grow from 6.0 billion metric tons in 2005 to 6.9 billion metric tons in 2030, an increase of 15 percent (see *AEO2008*), while emissions attributable to buildings would grow to 2.9 billion tons, an increase of 26 percent.

As shown in Table 16.2.2 in the *AEO2008* Reference Case, the cumulative U.S. energy-related power sector CO_2 emissions between 2012 and 2042 are described at about 86 billion metric tons. The estimated cumulative CO_2 emission reductions from a residential cooking product efficiency standard (shown as a range of alternative Trial Standard Levels) during this same 30-year period are indicated in Table 16.2.1. Estimated CO_2 emission reductions in Table 16.2.1 come from two sources: electricity generation (i.e., power plants) and fossil fuel-fired appliances. The estimated CO_2 emission reductions from electricity generation are calculated using the NEMS-BT model. The estimated CO_2 emission reductions from fossil fuel-fired appliances (i.e., gas cooking products) are derived from emissions factors for residential and commercial natural gas combustion.

Table 16.2.1 Impact of Conventional Cooking Product and Microwave Oven Efficiency Standards on Cumulative Energy-Related Emissions of CO_2 between 2012-2042 by Trial Standard Level (Million Metric Tons of CO_2)

	Trial Standard Levels			
	TSL 1	**TSL 2**	**TSL 3**	**TSL 4**
Conventional Cooking Products (CCP)	-13.74	-15.46	-23.39	-34.96
Microwave Ovens (MWO) EF	- 22.88	-33.46	-53.89	-74.67
Total	-36.82	-48.92	-77.28	-109.63
Percent of Total Cumulative Emissions Reduction from 2012 to 2042 compared with the AEO 2008 Reference Case	-0.042	-0.057	-0.090	-0.127

* All results in million metric tons, equivalent to 1.1 short tons and negative values refer to a reduction compared with the Base Case.

The estimated savings shown in Table 16.2.1, which are at most 0.127 percent of U.S. energy-related emissions of CO_2 (total emissions reported for TSL 4 in Table 16.2.1), comprise an even smaller fraction of U.S. emissions of greenhouse gases and of world emissions of greenhouse gases. However, the savings would likely reduce overall U.S. CO_2 emissions, as compared to U.S. CO_2 emissions absent an increase in the required efficiency of residential cooking products and microwave ovens.

The Incremental Impact of the Rule on Climate Change

It is difficult to correlate specific emission rates with atmospheric concentrations of CO_2 and specific atmospheric concentrations with future temperatures because the IPCC Report describes a clear lag in the climate system between any given concentration of CO_2 (even if maintained for long periods) and the subsequent average worldwide and regional temperature, precipitation, and extreme weather regimes. For example, a major determinant of climate response is "equilibrium climate sensitivity", a measure of the climate system response to sustained radioactive forcing. It is defined as the global average surface warming following a doubling of carbon dioxide concentrations. The IPCC Report describes its estimated, numeric value as about 3°C, but the likely range of that value is 2°C to 4.5°C, with cloud feedbacks the largest source of uncertainty. Further, as illustrated above, the IPCC Report scenarios for stabilization rates are presented in terms of a range of concentrations, which then correlates to a range of temperature changes. Thus, climate sensitivity is a key uncertainty for CO_2 mitigation scenarios that aim to meet specific temperature levels.

Because of how complex global climate systems are, it is difficult to know to what extent and when particular CO_2 emissions rates will impact global warming. However, as Table 16.2.1 indicates, the Rule will likely reduce CO_2 emissions rates from the fossil fuel sector.

16.2.4 Analytical Methods for Air Emissions

NEMS-BT incorporates capabilities to assess compliance with SO_2 restrictions specified in the Clean Air Act and its amendments. Clean air act provisions include New Source Performance Standards, and Revised New Source Performance Standards. The version of NEMS-BT in 2008 also included provisions for the CAIR, which imposes stricter restrictions on SO_2 and NO_X for some states, and the CAMR, which imposed a national Hg constraint. As discussed earlier is section 16.2.2, on December 23, 2008, the D.C. Circuit decided to allow CAIR to remain in effect until it is replaced by a rule consistent with the court's earlier opinion. Carolina v. Environmental Protection Agency, 550 F.3d 1176 (D.C. Cir. 2008) (remand of vacatur). But actions taken on February 8, 2008 by the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued in its decision in State of New Jersey, *et al.* v. Environmental Protection Agency, remain in effect vacating the CAMR. Although the constraints on Hg in CAMR have since been vacated by a court decision, the *AEO2008* Reference Case assumes that emissions of Hg would decline over time as shown in Table 16.2.2.

Because the courts vacated CAMR, the 2008 version of NEMS-BT could not be used directly to estimate emissions impacts for Hg. Instead, DOE established a range of Hg reductions due to standards. DOE's high estimate used a Hg emission rate based on the *AEO2008*. Because virtually all Hg emitted from electricity generation is from coal-fired power plants, DOE based the emission rate from the tons of Hg emitted per TWh of coal-generated electricity. DOE based the emission rate on the average value reported in the *AEO2008* for the year 2006. This emission rate is 0.0230 tons per TWh (0.0253 short tons/TWh). DOE's low estimate was based on the use of an emission rate for new combined-cycle gas plants as provided in the NEMS-BT. The emission rate for this generation technology is 0.000 tons per TWh. To estimate the reduction in Hg emissions from the power sector, DOE multiplied the emission rate by the reduction in coal-generated electricity due to the standards considered as determined in the utility impact analysis (see Chapter 14, Utility Impact Analysis). The estimated changes in Hg emissions are shown by TSL for cooking products in Table 16.2.3 and Table 16.2.4 for the period from 2012 to 2042.

Coal-fired electric generation is the single largest source of electricity in the United States. Because the mix of coals used significantly affects the emissions produced, the model includes a detailed representation of coal supply. The model considers the rank of the coal as well as the sulfur contents of the fuel used when determining optimal dispatch.

Within the NEMS-BT model, planning options for achieving emissions restrictions in the Clean Air Act Amendments include installing pollution control equipment on existing power plants and building new power plants with low emission rates. These methods for reducing emission are compared to dispatching options such as fuel switching and allowance trading. Environmental regulations also affect capacity expansion decisions. For instance, new plants are not allocated SO_2 emissions allowances according to the Clean Air Act Amendments. Consequently, the decision to build a particular capacity type must consider the cost (if any) of obtaining sufficient allowances. This could involve purchasing allowances or over complying at an existing unit.

Modeling of SO_2 trading tends to imply that the physical emissions effects will be zero, as long as emissions are at the allowed ceiling. Because SO_2 has been regulated with emissions caps for more than a decade, and no emissions reductions are reported from the NEMS-BT forecast model, DOE does not report SO_2 results here. This assumption is consistent with previous DOE environmental assessment documents.

As noted in Chapter 14, NEMS-BT model forecasts end in year 2030. Emissions impacts beyond 2030 were extrapolated for this rulemaking in Table 16.2.3 and 16.2.4.

16.2.5 Effects on Power Plant Emissions

Table 16.2.2 shows reference power plant emissions in selected years along with the change from the *AEO2008* Reference Case. The Reference case emissions are the emissions shown by the NEMS-BT model to result if none of the TSLs are promulgated.

Table 16.2.2 Power Sector Emissions Forecast from *AEO2008* Reference Case

NEMS-BT Results*:						
	2005	**2010**	**2015**	**2020**	**2025**	**2030**
CO_2 (Million metric tons/year)**	2,397	2,413	2,519	2,627	2,771	2,948
NO_X (Thousand metric tons/year)[†]	3,301	2,115	1,911	1,917	1,939	1,962
Hg (metric tons/year)[†]	46.92	33.78	22.46	17.44	15.32	13.56

* All results in metric tons, equivalent to 1.1 short tons and negative values refer to a reduction compared with the Base Case

** Comparable to Table A17 of *AEO2008*: Electric Generators

† Comparable to Table A8 of *AEO2008*: Emissions

Table 16.2.3 and Table 16.2.4 show the estimated changes in power plant emissions in selected years for all the TSLs. Changes in NO_X and Hg emissions from power plants are shown in these tables. Changes in CO_2 emissions from all sources are also shown in these tables.

Compared to the anticipated reference case emissions impacts forecast shown in Table 16.2.2, changes in emission levels shown in Table 16.2.3 though 16.2.4 are extremely small.

Table 16.2.3 Power Sector Emissions Impact Forecasts for Conventional Cooking Products

NEMS-BT Results*	Difference from AEO2008 Reference Case								
						Extrapolation			Total
	2012	2015	2020	2025	2030	2035	2040	2042	2012-2042
Trial Standard Level 1									
CO_2 (Mt/a)	-0.09	-0.13	-0.14	-0.19	-0.25	-0.25	-0.25	-0.25	**-6.02**
NOx (kt/a)	0.00	-0.02	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	**-0.61**
Hg (t/a)									
High	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	**-0.15**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 2									
CO_2 (Mt/a)	-0.11	-0.16	-0.18	-0.24	-0.33	-0.33	-0.33	-0.33	**-7.74**
NOx (kt/a)	0.00	-0.02	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	**-0.78**
Hg (t/a)									
High	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	**-0.19**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 3									
CO_2 (Mt/a)	-0.14	-0.21	-0.24	-0.34	-0.48	-0.48	-0.48	-0.48	**-11.11**
NOx (kt/a)	0.00	-0.03	-0.01	-0.03	-0.05	-0.05	-0.05	-0.05	**-1.12**
Hg (t/a)									
High	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	**-0.28**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 4									
CO_2 (Mt/a)	-0.19	-0.30	-0.35	-0.51	-0.74	-0.74	-0.74	-0.74	**-16.76**
Hg (t/a)									
High	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	**-0.41**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

* All results in metric tons (t), equivalent to 1.1 short tons

Table 16.2.4 Power Sector Emissions Impact Forecasts for Microwave Oven Energy Factor

NEMS-BT Results*	Difference from AEO2008 Reference Case								
						Extrapolation			Total
	2012	2015	2020	2025	2030	2035	2040	2042	2012-2042
Trial Standard Level 1									
CO_2 (Mt/a)	0.00	-0.55	-0.78	-0.84	-0.80	-0.80	-0.80	-0.80	**-22.88**
NO_x (kt/a)	0.00	-0.08	-0.04	-0.10	-0.09	-0.09	-0.09	-0.09	**-2.55**
Hg (t/a)									
High	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	**-0.46**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 2									
CO_2 (Mt/a)	0.00	-0.78	-1.06	-1.21	-1.21	-1.21	-1.21	-1.21	**-33.46**
NO_x (kt/a)	0.00	-0.11	-0.06	-0.14	-0.14	-0.14	-0.14	-0.14	**-3.75**
Hg (t/a)									
High	0.00	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	**-0.68**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 3									
CO_2 (Mt/a)	0.00	-1.24	-1.63	-1.93	-1.98	-1.98	-1.98	-1.98	**-53.89**
NO_x (kt/a)	0.00	-0.17	-0.09	-0.22	-0.23	-0.23	-0.23	-0.23	**-6.06**
Hg (t/a)									
High	-0.01	-0.01	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04	**-1.10**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Trial Standard Level 4									
CO_2 (Mt/a)	0.00	-1.70	-2.20	-2.66	-2.78	-2.78	-2.78	-2.78	**-74.67**
NO_x (kt/a)	0.00	-0.24	-0.12	-0.30	-0.32	-0.32	-0.32	-0.32	**-8.42**
Hg (t/a)									
High	-0.01	-0.02	-0.04	-0.06	-0.06	-0.06	-0.06	-0.06	**-1.52**
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

* All results in metric tons (t), equivalent to 1.1 short tons

16.2.6 Effects on Building Emissions

For residential cooking products, impacts on household emissions and commercial building emissions, respectively, at the site are also reported. These estimates are based on exogenous emissions factors for residential and commercial natural gas combustion derived by the EPA's AP-42 report in conjunction with the energy savings predicted by the National Impacts Analysis (NIA) model because NEMS-BT does not account for these emissions at the site. Household emissions from residential microwave ovens are not reported because all savings are from electricity.

The emissions factors DOE used are derived from what are reported in the AP-42 for residential water heaters because no explicit listing was provided for cooking products. However, the AP-42 sources does provide a method for estimating the share of residential emissions from cooking products based on natural gas deliveries specific to a given region, but this approach was not easily applicable to the U.S. so is not performed here.[3 h] As well, given that emissions rates from end-use combustion are small compared to other emissions sources, it is not uncommon to see emissions factors from residential end uses reported in one general rate.[4 i] For these reasons, the Department opted to simply use the water heating emissions factor as a way of providing a rough estimates for the emissions savings associated with these efficiency standards, but acknowledging that these estimates are only general approximations.

Table 16.2.5 shows the estimated changes in building emissions in selected years for the conventional cooking product TSLs.

Table 16.2.5 Change in Household Emissions for Conventional Cooking Products

NEMS-BT Results*	Difference from AEO2008 Reference Case								
						Extrapolation			Total
	2012	2015	2020	2025	2030	2035	2040	2042	2012-2042
Trial Standard Level 1									
CO_2 (Mt/a)	-0.03	-0.11	-0.22	-0.29	-0.30	-0.30	-0.30	-0.30	**-7.72**
NOx (kt/a)	-0.02	-0.09	-0.18	-0.23	-0.24	-0.24	-0.24	-0.24	**-6.10**
Trial Standard Level 2									
CO_2 (Mt/a)	-0.03	-0.11	-0.22	-0.29	-0.30	-0.30	-0.30	-0.30	**-7.72**
NOx (kt/a)	-0.02	-0.09	-0.18	-0.23	-0.24	-0.24	-0.24	-0.24	**-6.10**
Trial Standard Level 3									
CO_2 (Mt/a)	-0.04	-0.16	-0.33	-0.45	-0.50	-0.50	-0.50	-0.50	**-12.28**
NOx (kt/a)	-0.03	-0.13	-0.26	-0.36	-0.40	-0.40	-0.40	-0.40	**-9.70**
Trial Standard Level 4									
CO_2 (Mt/a)	-0.06	-0.22	-0.47	-0.66	-0.76	-0.76	-0.76	-0.76	**-18.20**
NOx (kt/a)	-0.05	-0.18	-0.37	-0.52	-0.60	-0.60	-0.60	-0.60	**-14.38**

* All results in metric tons (t), equivalent to 1.1 short tons

16.2.7 Effects on Upstream Fuel-Cycle Emissions

Fuel-cycle emissions refer to the emissions associated with the amount of energy used in the upstream production and downstream consumption of electricity, including energy used at the power plant. Upstream processes include the mining of coal or extraction of natural gas, physical preparatory and cleaning processes, and transportation to the power plant. The NEMS-BT does a thorough accounting of emissions at the power plant due to downstream energy

[h] The AP-42 source does list an approach for how to estimate residential cooking related emissions as a function of the share of total gas deliveries (http://www.epa.gov/ttn/chief/eiip/techreport/volume03/ng.pdf).

[i] See section 3.2 of a AGA report.

consumption, but does not account for upstream emissions (i.e., emissions from energy losses during coal and natural gas production). Thus, this analysis reports only power plant emissions.

However, previous DOE environmental assessment documents have developed qualitative estimates of affects on upstream fuel-cycle emissions. These emissions factors provide the reader with a sense of the possible magnitude of upstream effects. These upstream emissions would be in addition to emissions from direct combustion. Relative to the entire fuel cycle, estimates based on the work of Dr. Mark DeLuchi, and reported in earlier DOE environmental assessment documents, find that an amount approximately equal to eight percent, by mass, of emissions (including SO_2) from coal production are due to mining, preparation that includes cleaning the coal, and transportation from the mine to the power plant.[5] Transportation emissions include emissions from the fuel used by the mode of transportation that moves the coal from the mine to the power plant.

In addition, based on Dr. DeLuchi's work, DOE estimated that approximately an amount equal to 14 percent of emissions from natural gas production result from upstream processes. Emission factor estimates and corresponding percentages of contributions of upstream emissions from coal and natural gas production, relative to power plant emissions, are shown in Table 16.2.6 for CO_2 and NOx. The percentages are relative to power plant emissions and provide a means to estimate upstream emission savings based on changes in emissions from power plants. The percentage effects presented in Table 16.2.6 provides a qualitative approach to viewing effects on fuel cycle emissions. The previous section indicates slight overall reductions in CO_2 and NOx. Thus, very small reductions in upstream emissions of air pollutant could be expected. This approach does not address Hg emissions.

Table 16.2.6 Estimated Upstream Emissions of Air Pollutants as a Percentage of Direct Power Plant Combustion Emissions

Pollutant	Percent of Coal Combustion Emissions	Percent of Natural Gas Combustion Emissions
CO_2	2.7	11.9
NOx	5.8	40

16.2.8 Economic Value of Emission Reductions

In examining the impact of potential standards, DOE assessed potential monetary benefits from reduced emissions of CO_2, NO_x, Hg, and SO_2 associated with this rulemaking.

With regard to CO_2, the monetary estimates presented below in Tables 16.2.10 through 16.2.13 are based on an assumption of no benefit to an average benefit value reported by the

Intergovernmental Panel on Climate Change (IPCC).[j] It is important to note that the IPCC estimate used as the upper bound value was derived from an estimate of the mean value of worldwide impacts from potential climate impacts caused by CO_2 emissions, and not just the effects likely to occur within the United States. As DOE considers a monetary value for CO_2 emission reductions, the value should be restricted to a representation of those costs/benefits likely to be experienced in the United States. As DOE expects that such values would be lower than comparable global values, however, there currently are no consensus estimates for the U.S. benefits likely to result from CO_2 emission reductions. However, DOE believes it is appropriate to use U.S. benefit values, where available, and not world benefit values in its analysis.[k] Because U.S. specific estimates are not available, and DOE did not receive any additional information that would help serve to narrow the proposed range as a representative range for domestic U.S. benefits, DOE believes it is appropriate to propose the global mean value as an appropriate upper bound U.S. value for purposes of sensitivity analysis.

Given the uncertainty surrounding estimates of the societal cost of carbon (SCC), relying on any single study may be inadvisable since its estimate of the SCC will depend on many assumptions made by its authors. The Working Group II's contribution to the Fourth Assessment Report of the IPCC notes that:

> The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.[6]

Because of this uncertainty, DOE is relying on research performed by Tol,[7] which was presented in the IPCC's Fourth Assessment Report, and was a comprehensive meta-analysis of estimates for the value of SCC. As a result, DOE is relying on the Tol study reported by the IPCC as the basis for its analysis.

DOE continues to believe that the most appropriate monetary values for consideration in the development of efficiency standards are those drawn from studies that attempt to estimate the present value of the marginal economic benefits likely to result from reducing greenhouse gas

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[j] During the preparation of its most recent review of the state of climate science, the Intergovernmental Panel on Climate Change (IPCC) identified various estimates of the present value of reducing carbon-dioxide emissions by one ton over the life that these emissions would remain in the atmosphere. The estimates reviewed by the IPCC spanned a range of values. In the absence of a consensus on any single estimate of the monetary value of CO_2 emissions, DOE used the estimates identified by the study cited in Summary for Policymakers prepared by Working Group II of the IPCC's Fourth Assessment Report to estimate the potential monetary value of CO_2 reductions likely to result from standards finalized in this rulemaking. According to IPCC, the mean social cost of carbon (SCC) reported in studies published in peer-reviewed journals was $43 per ton of carbon. This translates into about $12 per ton of carbon dioxide. The literature review (Tol 2005) from which this mean was derived did not report the year in which these dollars were denominated. However, we understand this estimate was denominated in 1995 dollars. Updating that estimate to 2007 dollars yields a SCC of $15 per ton of carbon dioxide.

[k] In contrast, most of the estimates of costs and benefits of increasing the efficiency of residential cooking products include only economic values of impacts that would be experienced in the U.S. For example, in determining impacts on manufacturers, DOE generally does not consider impacts that occur solely outside of the United States.

emissions, rather than estimates that are based on the market value of emission allowances under existing cap and trade programs or estimates that are based on the cost of reducing emissions - both of which are largely determined by policy decisions that set the timing and extent of emission reductions and do not necessarily reflect the benefit of reductions. DOE also believes that the studies it relies upon generally should be studies that were the subject of a peer review process and were published in reputable journals.

For this analysis, DOE is essentially proposing to rely on a range of values based on the values presented in the Tol studay. Additionally, DOE has applied an annual growth rate of 2.4 percent to the value of SCC, as suggested by the IPCC Working Group II,[8] based on estimated increases in damages from future emissions reported in published studies. Because the values in the Tol study were presented in 1995 dollars, DOE is assigning a range for the SCC of $0 to $20 (in $2007) per ton of CO_2 emissions.

DOE is proposing to use the median estimated social cost of CO_2 as an upper bound of the range. This value is based on the Tol studay, which reviewed 103 estimates of the SCC from 28 published studies, and concluded that when only peer-reviewed studies published in recognized journals are considered, “that climate change impacts may be very uncertain but [it] is unlikely that the marginal damage costs of carbon dioxide emissions exceed $50 per ton carbon [comparable to a 2007 value of $20 per ton carbon dioxide when expressed in 2007 U.S. dollars with a 2.4% growth rate].”

In proposing a lower bound of $0 for the estimated range, DOE agrees with the IPCC Working Group II report that “significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems”,[9] and, thus, tentatively concludes that a global value of zero for reducing emissions cannot be justified. However, DOE also believes that it is reasonable to allow for the possibility that the U.S. portion of the global cost of carbon dioxide emissions may be quite low. In fact, some of the studies looked at in Tol reported negative values for the SCC. DOE is using U.S. benefit values, and not world benefit values, in its analysis, and, further, DOE believes that U.S. domestic values will be lower than the global values. Additionally, the statutory criteria in EPCA do not require consideration of global effects. Therefore, DOE is proposing to use a lower bound of $0 per ton of CO_2 emissions in estimating the potential benefits of today’s proposed rule.

The resulting estimates of the potential range of net present value benefits associated with the reduction of CO_2 emissions are reflected in Tables 16.2.7 and 16.2.8.

Table 16.2.7 Estimates of Savings from CO_2 Emissions Reductions under Conventional Cooking Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative CO_2 Emission Reductions (Million metric tons)	Value of Estimated CO_2 Emission Reductions Based on IPCC Range at 7% Discount Rate (Million 2007$)	Value of Estimated CO_2 Emission Reductions Based on IPCC Range at 3% Discount Rate (Million 2007$)
TSL 1	13.74	$0 – $109	$0 – $241
TSL 2	15.46	$0 – $122	$0 – $270
TSL 3	23.39	$0 – $182	$0 – $408
TSL 4	34.96	$0 – $269	$0 – $610

Table 16.2.8 Estimates of Savings from CO_2 Emissions Reductions under Microwave Oven Energy Factor Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative CO_2 Emission Reductions (Million metric tons)	Value of Estimated CO_2 Emission Reductions Based on IPCC Range at 7% Discount Rate (Million 2007$)	Value of Estimated CO_2 Emission Reductions Based on IPCC Range at 3% Discount Rate (Million 2007$)
TSL 1	22.88	$0 – $192	$0 – $404
TSL 2	33.46	$0 – $277	$0 – $589
TSL 3	53.89	$0 – $443	$0 – $948
TSL 4	74.67	$0 – $612	$0 – $1313

DOE also investigated the potential monetary impact resulting from the impact of potential efficiency standards on NO_x and Hg emissions.

As discussed earlier, with respect to NO_x the CAIR rule has been vacated by the courts, so projected annual NO_x allowances from NEMS-BT are no longer relevant. Therefore, DOE' estimates of NO_x emissions are not controlled by a nationwide regulatory system. For the range of NO_x reduction estimates and Hg reduction estimates, DOE estimated the national monetized benefits of emissions reductions based on environmental damage estimates from the literature. Available estimates suggest a very wide range of monetary values for NO_x emissions, ranging from $370 per ton to $3,800 per ton of NO_x from stationary sources, measured in 2001$ or a range of $421 per ton to $4,326 per ton in 2006$.[10] The resulting estimates of the potential range of the present value benefits associated with the national reduction of NO_x are presented in Tables 16.2.9 through 16.2.10. Because DOE estimated NO_x emissions with high and low emission rate estimates, two sets of results are presented for each product.

Table 16.2.9 Monetary Savings from NO_X Emissions Reductions under Conventional Cooking Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative NO_X Emission Reductions (Thousand metric tons)	Value of Estimated NO_X Emission Reductions at 7% Discount Rate (Million 2006$)	Value of Estimated NO_X Emission Reductions at 3% Discount Rate (Million 2006$)
TSL 1	6.71	$0.7 – $7.3	$1.5 – $15.4
TSL 2	6.88	$0.7 – $7.5	$1.5– $15.7
TSL 3	10.82	$1.1 – $11.5	$2.4 – $24.5
TSL 4	16.07	$1.6 – $16.8	$3.5 – $36.1

Table 16.2.10 Monetary Savings from NO_X Emissions Reductions under Microwave Oven Energy Factor Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative NO_X Emission Reductions (Thousand metric tons)	Value of Estimated NO_X Emission Reductions at 7% Discount Rate (Million 2006$)	Value of Estimated NO_X Emission Reductions at 3% Discount Rate (Million 2006$)
TSL 1	2.55	$0.3 – $3.2	$0.6 – $6.1
TSL 2	3.75	$0.4 – $4.6	$0.9 – $8.9
TSL 3	6.06	$0.7 – $7.3	$1.4 – $14.4
TSL 4	8.42	$1.0 – $10.2	$1.9 – $19.9

DOE has determined that the basic science linking mercury emissions from power plants to impacts on humans is considered highly uncertain. However, DOE identified two estimates of the environmental damages of mercury based on two estimates of the adverse impact of childhood exposure to methyl mercury on IQ for American children, and subsequent loss of lifetime economic productivity resulting from these IQ losses. The high-end estimate is based on an estimate of the current aggregate cost of the loss of IQ in American children that results from exposure to mercury of U.S. power plant origin ($1.3 billion per year in 2000$), which translates to $31.7 million per ton emitted per year (2006$).[11] The low-end estimate was $664,000 per ton emitted in 2004$ or $709,000 per ton in 2006$, which DOE derived from a published evaluation of mercury control using different methods and assumptions from the first study, but also based on the present value of the lifetime earnings of children exposed.[12] [1] The resulting estimates of the potential range of the present value benefits associated with the national reduction of Hg are presented in Tables 16.2.11 and 16.2.12. DOE estimated Hg emissions with high and low emission rate estimates. But because the low emission rate estimate is zero, there is only the need to provide results based on the high Hg emission rate estimate.

[1] The estimate was derived by back-calculating the annual benefits per ton from the net present value of benefits reported in the study.

Table 16.2.11 High Emission Rate Estimates of Monetary Savings from Hg Emissions Reductions under Conventional Cooking Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative Hg Emission Reductions (metric tons)	Value of Estimated Hg Emission Reductions at 7% Discount Rate (Million 2006$)	Value of Estimated Hg Emission Reductions at 3% Discount Rate (Million 2006$)
TSL 1	0.15	$0.0 – $1.3	$0.1 – $2.6
TSL 2	0.19	$0.0 – $1.6	$0.1 – $3.3
TSL 3	0.28	$0.1 – $2.2	$0.1 – $4.6
TSL 4	0.41	$0.1 – $3.3	$0.2 – $6.9

Table 16.2.12 High Emission Rate Estimates of Monetary Savings from Hg Emissions Reductions under Microwave Oven Energy Factor Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative Hg Emission Reductions (metric tons)	Value of Estimated Hg Emission Reductions at 7% Discount Rate (Million 2006$)	Value of Estimated Hg Emission Reductions at 3% Discount Rate (Million 2006$)
TSL 1	0.46	$0.1 – $3.7	$0.2 – $7.8
TSL 2	0.68	$0.1 – $5.4	$0.2 – $11.3
TSL 3	1.10	$0.2 – $8.6	$0.4 – $18.2
TSL 4	1.52	$0.3 – $11.8	$0.6 – $25.2

With regard to SO_2 emissions, unlike the other pollutants considered in this analysis, these emissions have for some time been subject to a national cap with corresponding annual allowances openly traded; therefore, considerable market experience with these instruments has already been accumulated. It has been argued that imposition of any standard that lowers U.S. national electricity consumption creates beneficial downward pressure on the prices of these allowances, and this cost reduction benefit should be considered in any analysis of a proposed standard. While this assertion is fundamentally sound (i.e., reduced electricity demand should *ceteris paribus* bring about lower SO_2 allowance prices) there are a myriad of complications impeding any meaningful quantification of any associated benefit. While complexity of analysis alone clearly cannot justify disregarding a potential consequence of a standard, DOE additionally believes these benefits to be both volatile and *de minimis* when compared to the direct effects of a standard as estimated in this analysis.

Some of the problems to be confronted in an allowance price effect forecast are:

- Only any net lowering of the total allowance bill to generators free of transfers is the potential source of a benefit. Any such compliance cost saving would need to be accurately estimated, and this effect is no different from the benefit derived from a cost reduction for other inputs, such as fuel. When the SO_2 allowance market that was created in 1995 under the Clean Air Act Amendments began, initial allowance allocations were directly granted to large *affected units* based on their historic (1985-87) use of fuel. For

30 years, allowances for the following year are issued every spring at a declining rate to these entitled parties, and thereafter can be freely used, traded, or banked. Some additional allowances are allocated in diverse ways (e.g. as rewards to generators installing control equipment). In other words, the entitled generators holding emission rights are losers when the value of allowances declines, while the buyers of allowances are gainers. Before they are used, allowances may be traded many times at prices reflecting the marginal not average cost of compliance.

- The trading system allows for allowance banking. Consequently, any observed change in a forecast year could represent the manifestation of market fundamentals but could similarly just indicate deposit or withdrawal of allowances. In general, used allowances have fallen short of the cap so emissions may exceed the specified cap for future years.

- Control efforts could further reduce the SO_2 cap for some jurisdictions, creating regulatory uncertainty that perturbs the allowance market. The issuance of the proposed and final CAIR rules were likely contributing factors to allowance price increases leading to a dramatic 2005 allowance price spike. While prices had already fallen far below their historic highs by the time CAIR was vacated in the summer of 2008, spot allowance prices nonetheless made a further precipitous drop following the D.C. Circuit Court ruling.

- Because allowances can be traded freely by generators, brokers, and investors, they can serve as financial instruments, and, especially since 2003, allowance prices have been volatile. Between 2000, when a tightened Clean Air Amendment cap came into force, and 2007, allowances traded between a low of about \$120/short ton in 2002 and a high of about \$1600/short ton, with the 2005 spike being particularly dramatic.[13] [14] Since there is no reason to believe that these conditions will alter over the life of a proposed standard, the challenge of forecasting prices is much more complex than a simple supply-demand balance might suggest. Also, note that any quantification of the benefit likely depends on the level of prices as well as their net change. To believe that a simple delta in the prices could be used to estimate the benefit is to believe that the same numerical reduction in price would result from the standard whether the prevailing trading price were \$100 or \$1000 per short ton.

As noted earlier, the forecasting tool used for this analysis is the *AEO2008* version of NEMS-BT, which generates forecasts of both SO_2 emissions and allowance prices. Unfortunately, this model was released before CAIR was overturned so its forecast enforces the tighter CAIR cap in the affected east of country, and does not represent current conditions. Given the timing of the CAIR ruling relative to the progress of this analysis, attaining projections absent CAIR has not been possible. Nonetheless, as a indicative bounding case, the net average price delta for the period 2012 to 2030 for the maximum technologically feasible (Max Tech) TSLs reported by the *AEO2008* NEMS-BT are -0.02 percent for cooking products (TSL 4) and -0.05 percent for microwave ovens (TSL 4). These estimates represent the average of percentage changes from the interpolated Max Tech standards for each of the products in the EMM East region. DOE considers this effect to be inconsequential relative to other elements in the benefits analysis, and given the significant effort that would be required to develop a refined estimate, the SO_2 allowance price effect is not considered further in this analysis. If future analysis suggests that the SO_2 allowance price effect is both significant and estimable using NEMS-BT, it may be added to supporting material.

16.3 WETLAND, ENDANGERED AND THREATENED SPECIES, AND CULTURAL RESOURCES

DOE’s action is not site-specific, nor would it affect land disturbance or use due to cooking products being installed in residential buildings. Therefore, none of the TSLs are expected to affect the quality of wetlands, or threatened or endangered species. Further, this action is not expected to impact cultural resources such as historical or archaeological sites.

16.4 SOCIOECONOMIC IMPACTS

DOE's analysis has shown that the increase in the first cost of purchasing more efficient cooking products at the proposed standard level is completely offset by a reduction in the life-cycle cost (LCC) of owning a more efficient piece of equipment. In other words, the customer will pay less operating costs over the life of the equipment even through the first cost increases. The complete analysis and its conclusions are presented in Chapter 8 of the TSD.

For subgroups of low-income and senior consumers that purchase cooking products, DOE determined that the average LCC impact is similar to that for the full sample of consumers. Therefore, DOE concludes that the proposed action would have no significant socioeconomic impact. For a complete discussion on the LCC impacts on consumer subgroups, see Chapter 12 of the TSD.

Tables 16.4.1 and 16.4.2 show the mean LCC savings for both the full sample of consumers and subgroup of consumers for conventional cooking products and microwave ovens.

Table 16.4.1 Mean Life-Cycle Cost Savings for Consumers and Sub-Groups, Conventional Cooking Products

	Trial Standard Level			
	1	**2**	**3**	**4**
Electric Coil Cooktops				
All Consumers	NA	$4	$4	$4
Low-Income Consumer Subgroup	NA	$4	$4	$4
Senior-Only Consumer Subgroup	NA	$3	$3	$3
Electric Smooth Cooktops				
All Consumers	NA	NA	NA	-$238
Low-Income Consumer Subgroup	NA	NA	NA	-$238
Senior-Only Consumer Subgroup	NA	NA	NA	-$239
Gas Cooktops				
All Consumers	$15	$15	$15	-$8
Low-Income Consumer Subgroup	$21	$21	$21	-$1
Senior-Only Consumer Subgroup	$16	$16	$16	-$7
Electric Standard Ovens				
All Consumers	NA	$11	$11	-$50
Low-Income Consumer Subgroup	NA	$10	$10	-$51
Senior-Only Consumer Subgroup	NA	$7	$7	-$56
Electric Self-Cleaning Ovens				
All Consumers	NA	NA	NA	-$143
Low-Income Consumer Subgroup	NA	NA	NA	-$155
Senior-Only Consumer Subgroup	NA	NA	NA	-$205
Gas Standard Ovens				
All Consumers	$9	$9	$9	-$81
Low-Income Consumer Subgroup	$9	$9	$9	-$84
Senior-Only Consumer Subgroup	$9	$9	$9	-$78
Gas Self-Cleaning Ovens				
All Consumers	NA	NA	$3	-$4
Low-Income Consumer Subgroup	NA	NA	-$3	-$10
Senior-Only Consumer Subgroup	NA	NA	-$2	-$10

Table 16.4.2 Mean Life-Cycle Cost Savings for Consumers and Sub-Groups, Microwave Ovens

	Trial Standard Level			
	1	2	3	4
All Consumers	-$7	-$21	-$40	-$66
Low-Income Consumer Subgroup	-$7	-$20	-$40	-$66
Senior-Only Consumer Subgroup	-$8	-$21	-$40	-$67

16.5 ENVIRONMENTAL JUSTICE IMPACTS

According to Executive Order 12898 of February 11, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," DOE is required to examine the effect of more stringent energy-efficiency standards on (1) small businesses that either manufacture or use cooking products, (2) manufacturers of niche products related to cooking products, and (3) small businesses operated by disadvantaged or minority populations.

For conventional cooking products, DOE identified three manufacturers of gas-fired ovens, stoves, and cooktops with standing pilot lights. Two of the three manufacturers are classified as small businesses by the Small Business Administration. As described in the Manufacturer Impact Analysis, Chapter 13 of the TSD, though the small manufactures shared many of the concerns as the large manufacturer, the small businesses will be much more impacted by a standard that eliminates standing pilots. The two small businesses indicated that 25 percent or more of their entire production consists of such niche products, now that most manufacturers have switched to electronic ignition in their gas-fired cooking appliances. In addition to the elimination of standing pilots, any rule affecting products manufactured by these small businesses will impact them disproportionately because of their size and their focus on cooking appliances. However, due to the low number of competitors that agreed to be interviewed, DOE could not characterize this industry segment with a separate cash-flow analysis due to concerns about maintaining confidentiality. Therefore, DOE is able to only qualify the potential impacts to small businesses.

16.6 NOISE AND AESTHETICS

Improvements in efficiency of cooking products is expected to result from changes in the choice of components and other design features. These changes are described in Chapter 5 of this TSD. These design changes are not expected to change noise levels in comparison to equipment in today's market. Equipment that is currently manufactured in the existing market that would meet the proposed standards is no louder than less efficient equipment. Changes to the design to improve the efficiency levels are not anticipated to affect the equipment's aesthetics.

16.7 SUMMARY OF ENVIRONMENTAL IMPACTS

Table 16.7.1 and Table 16.7.2 summarize anticipated environmental impacts for each of the TSLs across all equipment types. Air quality impacts were modeled for each of the TSLs. The summary table shows cumulative changes in emissions for CO_2, NOx, and Hg over the period 2012 to 2042. The resulting changes in emission quantities are very small. Cumulative CO_2, NO_x, and Hg emissions show a decrease compared to the reference case. Hg emissions show a very small increase in cumulative emissions. This increase may result from the combined effects of emissions banking, a shift in how power plants are dispatched, or the timing within the model of when power plants are replaced.

Upstream fuel cycle emission of CO_2 and NO_x are described but not quantified in section 16.2.7. The text describes potential reductions in fuel cycle emissions as percentage of decreases in power plant emissions. This qualitative approach suggests that upstream fuel cycle emissions would decrease and provides a sense for the magnitude of effects, however DOE does not report actual estimates of the effects. This approach does not address Hg emissions.

Socioeconomic impacts are presented as changes in life cycle costs. No impacts are anticipated in the area of environmental justice; wetlands, endangered and threatened species, and cultural resources; or noise and aesthetics.

Table 16.7.1 Environmental Impact Analysis Results Summary for Conventional Cooking Products

Environmental Effects	Reference Case*	Trial Standard Level			
		1	2	3	4
Cumulative Total Emission Reductions**					
CO_2 (Million metric tons)	86,206	-13.74	-15.46	-23.39	-34.96
NO_X (Thousand tons)	60,796	-6.71	-6.88	-10.82	-16.07
Hg (tons)					
High Emission Rate Estimate	519	-0.15	-0.19	-0.28	-0.41
Low Emission Rate Estimate	519	0.00	0.00	0.00	0.00
Cumulative Power Sector Emission Reductions*					
CO_2 (Million metric tons)	86,207	-6.02	-7.74	-11.11	-16.76
NO_X (Thousand tons)	60,796	-0.61	-0.78	-1.12	-1.69
Hg (tons)					
High Emission Rate Estimate	519	-0.15	-0.19	-0.28	-0.41
Low Emission Rate Estimate	519	0.00	0.00	0.00	0.00
Cumulative Household Emission Reductions*					
CO_2 (Million metric tons)	-	-7.72	-7.72	-12.28	-18.20
NO_X (Thousand tons)	-	-6.10	-6.10	-9.70	-14.38
Fuel-Cycle (Upstream) Emissions	NA	***	***	***	***
Wetlands, Endangered and Threatened Species, Cultural Resources	NA	None	None	None	None
Socioeconomic Impacts - Mean LCC Savings†					
Electric Coil Cooktops					
All Consumers	-	NA	$4	$4	$4
Low-Income Consumer Subgroup	-	NA	$4	$4	$4
Senior-Only Consumer Subgroup	-	NA	$3	$3	$3
Electric Smooth Cooktops					
All Consumers	-	NA	NA	NA	-$238
Low-Income Consumer Subgroup	-	NA	NA	NA	-$238
Senior-Only Consumer Subgroup	-	NA	NA	NA	-$239
Gas Cooktops					
All Consumers	-	$15	$15	$15	-$8
Low-Income Consumer Subgroup	-	$21	$21	$21	-$1
Senior-Only Consumer Subgroup	-	$16	$16	$16	-$7
Electric Standard Ovens					
All Consumers	-	NA	$11	$11	-$50
Low-Income Consumer Subgroup	-	NA	$10	$10	-$51
Senior-Only Consumer Subgroup	-	NA	$7	$7	-$56
Electric Self-Cleaning Ovens					
All Consumers	-	NA	NA	NA	-$143
Low-Income Consumer Subgroup	-	NA	NA	NA	-$155
Senior-Only Consumer Subgroup	-	NA	NA	NA	-$205
Gas Standard Ovens					
All Consumers	-	$9	$9	$9	-$81
Low-Income Consumer Subgroup	-	$9	$9	$9	-$84
Senior-Only Consumer Subgroup	-	$9	$9	$9	-$78
Gas Self-Cleaning Ovens					
All Consumers	-	NA	NA	$3	-$4
Low-Income Consumer Subgroup	-	NA	NA	-$3	-$10
Senior-Only Consumer Subgroup	-	NA	NA	-$2	-$10

Environmental Effects	Reference Case*	Trial Standard Level			
		1	2	3	4
Environmental Justice	NA	††	††	††	††
Noise and Aesthetics	NA	None	None	None	None

* The reference case values reflect total cumulative emissions and life cycle cost s in the absence of an energy conservation standard.

** Cumulative total is over a time period from 2012 to 2042. Negative values refer to emission reductions.

*** DOE does not report actual estimates of the effects of standards on upstream emissions, but section 16.2.7 provides a sense for the possible magnitude of effects.

† Values refer to life-cycle cost savings over the equipment lifetime.

†† DOE identified two small businesses that produce gas cooking products but was not able to quantify potential impacts to these businesses.

Table 16.7.2 Environmental Impact Analysis Results Summary for Microwave Ovens

Environmental Effects	Reference Case*	Trial Standard Level			
		1	2	3	4
CO_2 (Million metric tons)	86,206	-22.88	-33.46	-53.89	-74.67
NO_X (Thousand tons)	60,796	-2.55	-3.75	-6.06	-8.42
Hg (tons)					
High Emission Rate Estimate	519	-0.46	-0.68	-1.10	-1.52
Low Emission Rate Estimate	519	0.00	0.00	0.00	0.00
Fuel-Cycle (Upstream) Emissions	NA	***	***	***	***
Wetlands, Endangered and Threatened Species, Cultural Resources	NA	None	None	None	None
Socioeconomic Impacts - Mean LCC Savings†					
All Consumers	-	-$7	-$21	-$40	-$66
Low-Income Consumer Subgroup	-	-$7	-$20	-$40	-$66
Senior-Only Consumer Subgroup	-	-$8	-$21	-$40	-$67
Environmental Justice	NA	None	None	None	None
Noise and Aesthetics	NA	None	None	None	None

* The reference case values reflect total cumulative emissions and life cycle cost s in the absence of an energy conservation standard.

** Cumulative total is over a time period from 2012 to 2042. Negative values refer to emission reductions. All emissions from power sector.

*** DOE does not report actual estimates of the effects of standards on upstream emissions, but section 16.2.7 provides a sense for the possible magnitude of effects.

† Values refer to life-cycle cost savings over the equipment lifetime.

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